THE EVALUATION OF A DEFORMABLE DIFFRACTION GRATING FOR A STIGMATIC EUV SPECTROHELIOMETER

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During the past six months the primary activities of the development program have been the preparations for the detailed laboratory tests of the first two toroidal gratings in the laboratory at the University of Padua, and the initial tests in the optical laboratory at ETH, Zürich of the more complex elastically deformable substrate for the fabrication of aspheric gratings. The paper describing the results of the initial measurements of the first two toroidal gratings was accepted for publication in Applied Optics. A preprint of the final version is attached to this progress report.

The laboratory spectrograph at the University of Padua is now ready for the detailed tests of the first toroidal gratings at extreme-ultraviolet (EUV) wavelengths using the (256 x 1024)-pixel open-structure MAMA detector tube with 25 x 25 microns^2 pixels. Two sets of pinholes have been fabricated by laser drilling by Melles Griot, Inc. and have been sent to Padua for mounting on the entrance slit of the spectrograph for the imaging tests. Each set consists of a linear array of ten pinholes, either 15 microns or 20 microns in diameter, separated by 250 microns. The total length of the array is 2.25 mm which can easily be accommodated within the 6.5 x 26 mm^2 active areas of the MAMA detector. A second pair of sets with spacings of 500 microns will also be ordered for the tests. The interface between the open-structure MAMA detector tube and the spectrograph has now been fully defined and ion-traps to prevent the detection of charged particles produced in the spectrograph have been fabricated (see Figure 1).

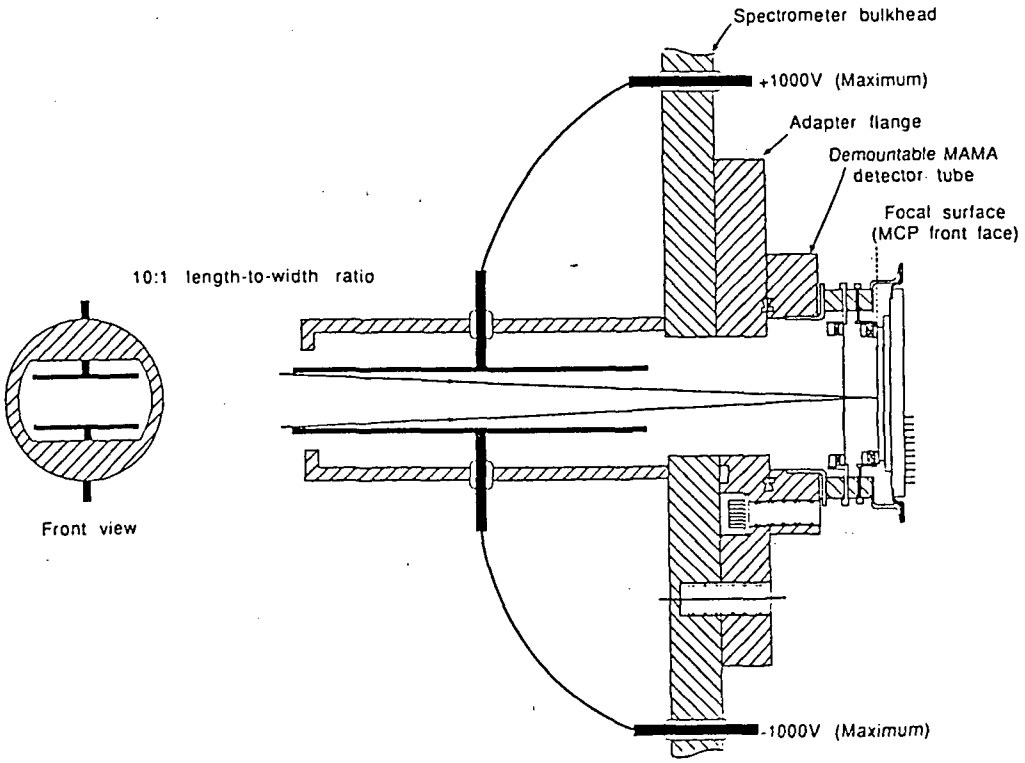


Figure 1. Schematic of the MAMA detector and ion-trap assembly for the imaging tests of the toroidal gratings using the Padua laboratory spectrograph.

The open-structure MAMA detector tube will employ a Galileo Electro-Optics curved-channel MCP fabricated from the new long-life (L^2 glass) and having a high channel input bias angle for maximum detection efficiency at EUV wavelengths. This MCP is currently being scrubbed at Stanford prior to installation in the open-structure MAMA detector tube. The test program in Padua is currently scheduled for a two week period at the end of August and the beginning of September.

The existing toroidal gratings are designed to operate at a focal ratio of f/15. In order to further improve the image quality, and to permit imaging with gratings having lower focal ratios, an aspheric surface is required. A more complex elastically deformable substrate has accordingly been fabricated to test this technique for fabricating aspheric gratings. If successful, this technique offers major advantages over computer controlled machining of aspheric surfaces since the relaxed spherical surface has no intermediate slope errors. This substrate (see Figure 2) has a focal length of 1 m and can accommodate a diffraction grating with a focal ratio of f/8.

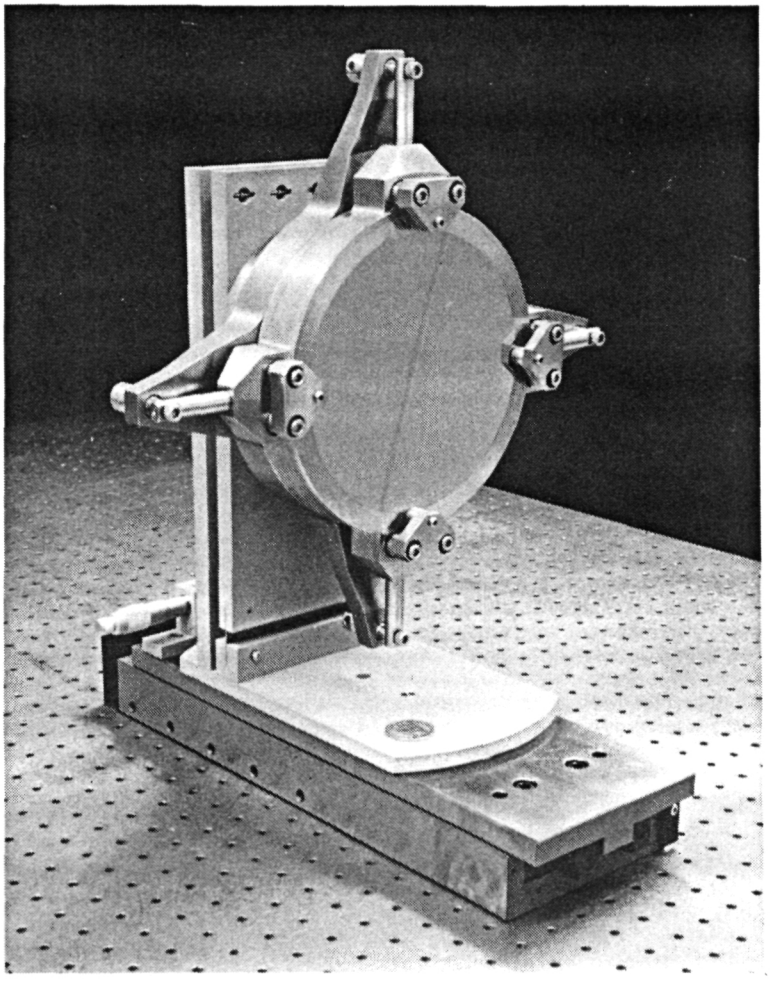


Figure 2. Elastically deformable substrate for the fabrication of aspheric diffraction gratings. Focal length 1 m, focal ratio f/8.

A schematic of a section of part of the substrate including one of the deforming actuators is shown in Figure 3.

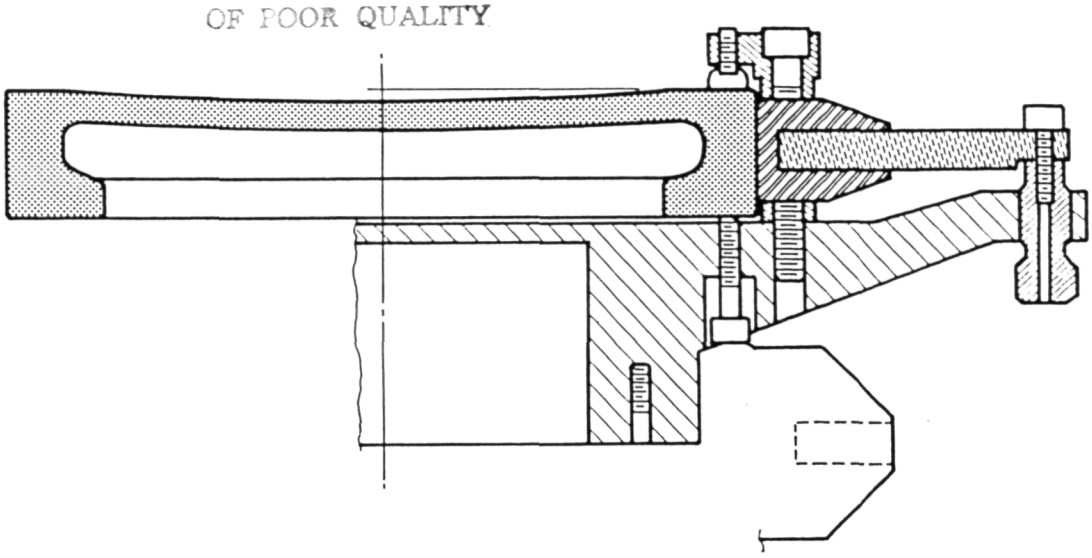


Figure 3. Schematic of part of the elastically deformable substrate for the fabrication of aspheric diffraction gratings showing one of the four deforming actuators.

Initial tests of the substrate using the modified Martin-Watt-Weinstein interferometer at ETH, Zürich (see Figure 4, see Figure 5a of the attached preprint for a schematic of the optical system) has shown that the surface is spherical to within the specification of ±1 fringe at 6325 Å (see Figure 5a).

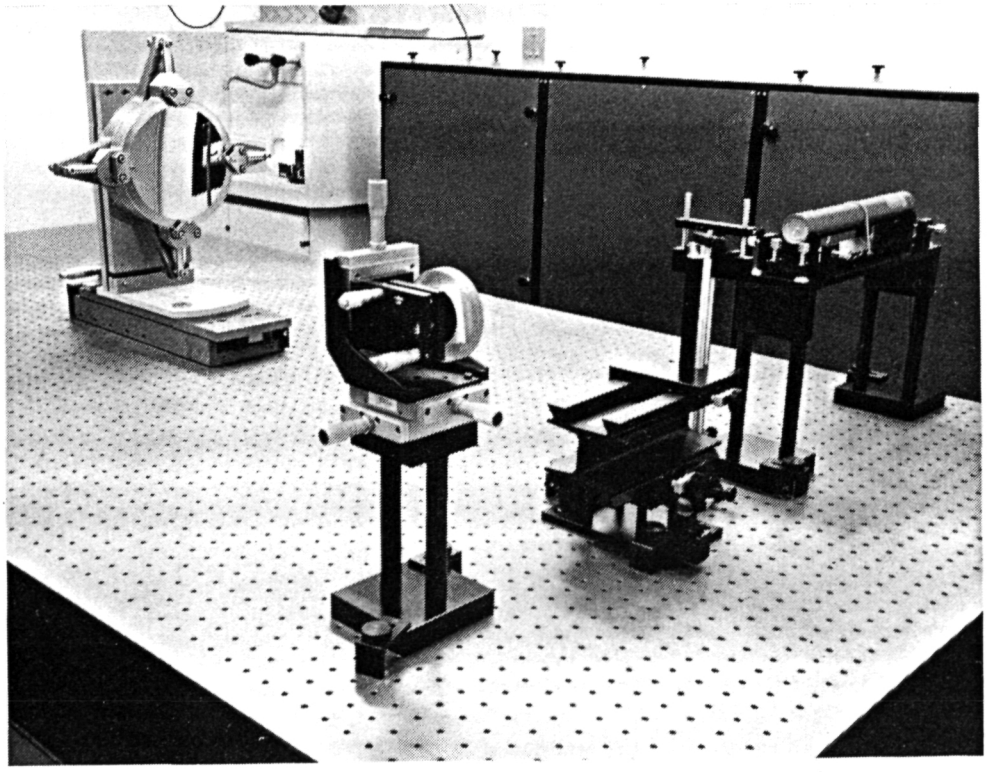
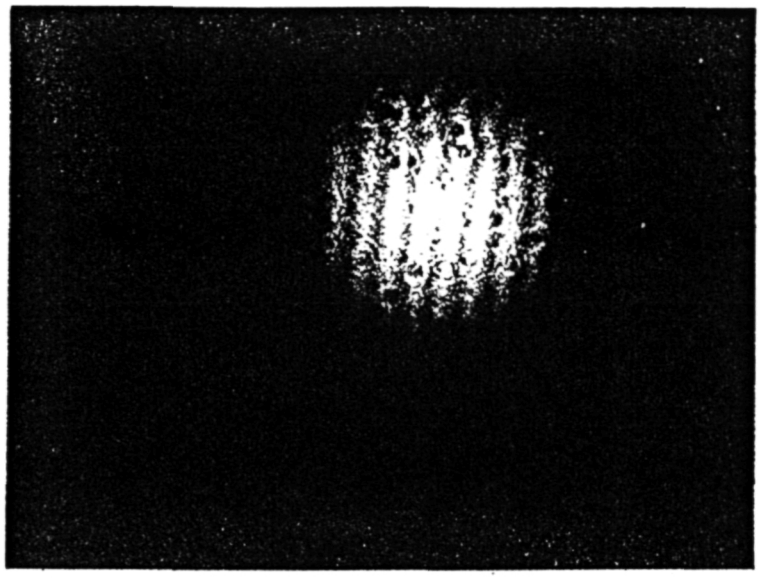
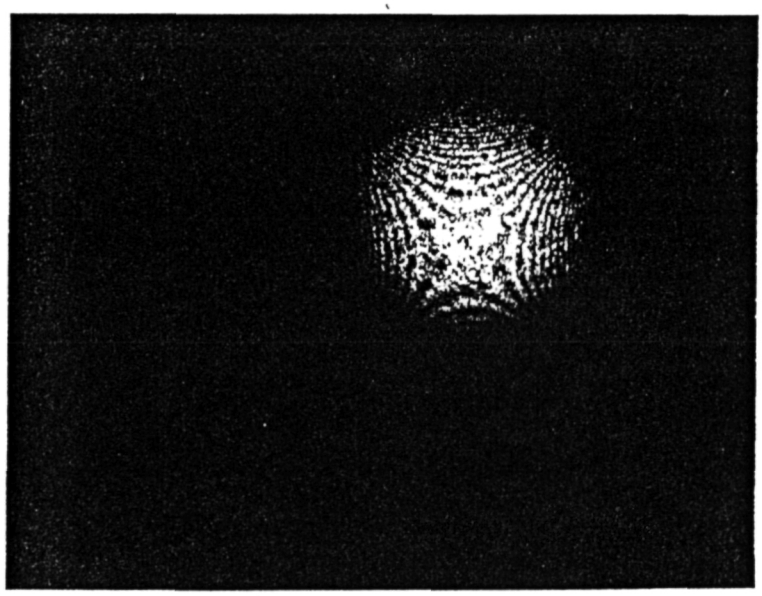


Figure 4. Elastically deformable substrate mounted on the modified Martin-Watt-Weinstein interferometer at ETH, Zürich.



(a)



(b)

Figure 5. Fringe patterns produced with the elastically deformable aspheric substrate.

a. Relaxed-spherical (off axis).
b. Deformed-toroidal (on axis).

The substrate was successfully deformed to produce a toroidal surface (see Figure 5b) and to induce coma (this figure is not yet available). Further evaluations of the substrate at ETH are planned in conjunction with the EUV tests of the toroidal gratings at Padua in August and September.

We have continued to refine our concept of a high-resolution EUV spectroheliometer employing a toroidal grating which is compatible with a Black Brant sounding rocket, and are continuing our discussions with Dr. S. K. Jain of the Indian Institute of Astrophysics at Bangalore, who is interested in participating in this project, probably through a collaboration with Prof. Huber, who is currently at the Space Science Department of the European Space Agency at ESTEC.

A proposal for a one year continuation of this program, to complete the studies of the toroidal and aspheric gratings has been submitted to NASA in response to the Space Physics Research and Analysis NRA. It is our intent to propose the spectroheliometer development and flight program when the Solar Physics Sounding Rocket NRA is issued next year.

Attachment "The Initial Evaluation of an Imaging Extreme Ultraviolet Spectrometer Employing a Single Toroidal Diffraction Grating" by M.C.E. Huber *et al.*